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A Study on the Optimization of High-Concentration Ammonia Nitrogen Chemical Treatment Process

Tae-Hwan JEONG[1], Su-Hye KIM[2], Woo-Taeg KWON[3]

[1. First Author] Researcher, Unionenv. CO. LTD., Korea, Email: jeongth7@naver.com
[2. Second Author] Researcher, Department of Environmental Health & Safety, Eulji University, Korea, Email: kagome00@naver.com
[3. Corresponding Author] Professor, Department of Environmental Health & Safety, Eulji University, Korea, Email: awtkw@eulji.ac.kr

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Abstract

Purpose: High concentrations of nitrogen exist in food wastewater, and when nitrogen is not properly treated and discharged, it can cause eutrophication in the aquatic ecosystem. **Research design, data and methodology:** In order to remove nitrogen using sodium hypochlorite, the BNCR tank was designed and installed in the step behind the biological treatment tank, and the data of pH, TOC, and T-N were collected after about a month of demonstration. **Results:** As a result of operating the BNCR tank, total nitrogen decreased by about 83% on average. The total nitrogen in the second sedimentation tank before going through the BNCR tank must be removed and finally discharged after nitrogen is removed above the legal standard of 60 mg/L. **Conclusions:** If BNCR tank is added to the process currently applied to nitrogen removal and operated, ammonia nitrogen can be removed more efficiently. However, the disadvantage is that nitric acid nitrogen and nitric acid nitrogen cannot be removed. If these disadvantages are supplemented and optimized in the future, it will be helpful for workplaces that are having difficulty removing nitrogen.

Keywords : Food Wastewater, Ammonia Nitrogen, BNCR Tank, Nitrogen Removal

JEL Classification Codes : I30, I31, I38

1. Introduction

High concentrations of organic matter and ammonia nitrogen are present in food wastewater. Usually, biological treatment is used to remove nutrients such as nitrogen and phosphorus. Various methods are being developed and optimized to treat nitrogen in wastewater, but all methods have advantages and disadvantages, so it is important to study which method to use in what circumstances and under what conditions. In addition, the removal of nitrogen can be said to be very important because problems such as eutrophication of the aquatic ecosystem can occur if the nutrient salts are not properly removed and finally discharged.

In this study, a process was designed to remove ammonia nitrogen present in food wastewater. After the biological treatment tank, an additional BNCR tank was installed to derive the total nitrogen removal rate through demonstration for about a month.

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2. Literature Review

Nitrogen is usually treated biologically and is treated through a nitrification-denitrification process. However, since additional organic carbon sources must be introduced for denitration, the ANAMMOX process that can compensate for these shortcomings is being actively studied. The ANAMMOX process has the advantage of not requiring an organic carbon source for denitrification (Lee & Kim, 2016). And since ANAMMOX uses nitric acid nitrogen, a partial nitrification process is required (Jo et al., 2015).

The CANON process applies partial nitrification and ANAMMOX at the same time, so that an external carbon source is not required and oxygen requirements are less than that of ordinary nitrification-denitrification processes (Jo et al., 2015).

The DEPHANOX process is a process that can remove both nitrogen and phosphorus. By maximizing the use of organic matter, nitric acid bacteria dominate the competition in nitric acid tanks, so the removal efficiency of ammonia nitrogen does not decrease even at low temperatures and short HRT (Lee et al., 2012).

The MBR process was developed to compensate for the shortcomings of the most basic active sludge process used in sewage treatment. It causes nitrification and denitrification at the same time (Jeong, 2018), and has the advantage of being able to process stably regardless of load fluctuations. Because it can maintain high concentrations of microorganisms, processing efficiency is high even in a short HRT. However, the nitrogen removal efficiency is not very high, and there is also a problem of separator contamination, so it is a construction method that needs to be improved (Jung & Hyun, 2020).

The PAC-A/O process is a method of applying both the activated sludge method in which powder activated carbon is administered and the oxygen-free/aerobic method. The method removes organic substances and chromaticity by adsorbing non-degradable toxic substances in industrial wastewater with powder-activated carbon (Jeong, 2018).

The oxygen-free-oxygen-free-oxygen process is a process in which denitrification occurs in an oxygen-free tank and nitrification occurs in an oxygen tank. In order for denitrification to occur in the second anaerobic tank, some of the inflow water is introduced into the second anaerobic tank to supply insufficient carbon source (Lee, 2005).

Methods such as A^2/O and SBR were developed as advanced treatment methods for removing nitrogen and phosphorus. Among them, the SBR method is a method that can be used in consideration of flexibility according to load fluctuations. It is easy to operate, can remove organic matter and remove nutrients, and has the advantage of reducing the site area. However, there is a limit to the flow rate that can be processed per day and is not suitable for large-scale treatment plants. (Kim et al., 2019)

The MBR method completely removes suspended substances and reduces the site area because it does not require a final precipitation tank. Although the MABR method developed here can reduce energy consumption by less than four times, membrane contamination can occur frequently. The MAfR method is a method of supplying hydrogen gas into the membrane. A biological membrane is formed on the outer surface of the membrane and the substrate in the water is consumed by bacteria (Ryoo et al., 2019).

The MES method is a method of removing organic matter and nitrogen and producing electrical energy using microbial electrochemical technology. In addition, it is continuously being developed with the aim of producing renewable energy such as hydrogen and methane as well as electric energy (Chai et al., 2020).

Currently, there is not much known about the nitrogen removal method using sodium hypochlorite, and patents filed in the early 2000s exist. There are few cases where the method has been included and applied within the treatment process currently in use.

3. Research Methods and Materials

Data was collected by operating the BNCR group for about a month from January 6, 2023 to February 6, 2023. The figure below is a flow chart of the process used in this study.

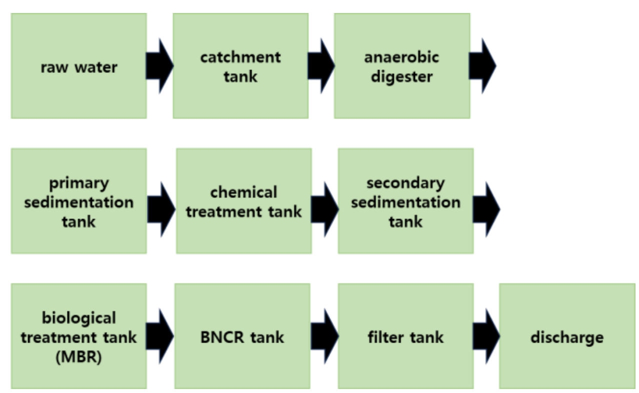

Figure 1: Food wastewater treatment system chart

In this study, a method of removing nitrogen by sodium hypochlorite was used, and the reaction equation is as follows.

$$2NH_3 + 2NaOCl \rightarrow N_2(\uparrow) + 3NaCl + 3H_2O$$

A BNCR tank was designed to remove ammonia nitrogen from food wastewater, and the figure below is a drawing of the BNCR tank.

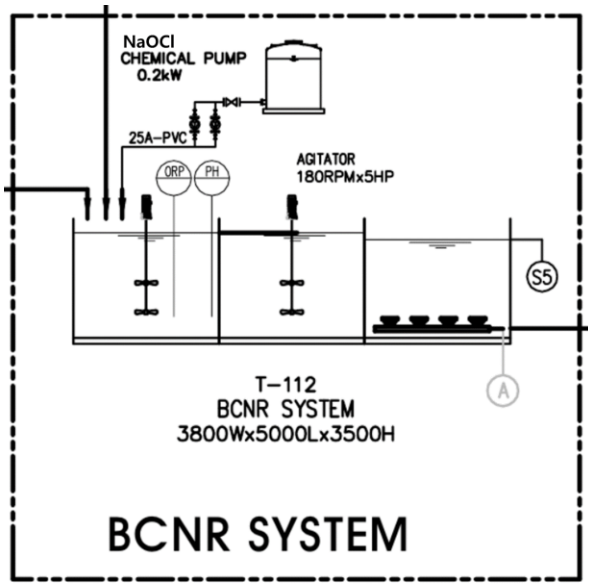

Figure 2: BNCR system

In the biological treatment tank, the blower is usually operated for 24 hours, but in this study, it was stopped for 4 hours and operated for 30 minutes to selectively remove only organic matter. If the organic material is not removed, a situation in which the organic material must be removed again after the denitration process may occur, so the biological treatment tank was passed.

Thereafter, it is introduced into the BNCR tank and nitrogen is removed using 1000 ppm of sodium hypochlorite.

4. Results and Discussion

The pH, TOC, and T-N values from the raw wastewater to the BNCR tank were measured, and the following graphs show the trend.

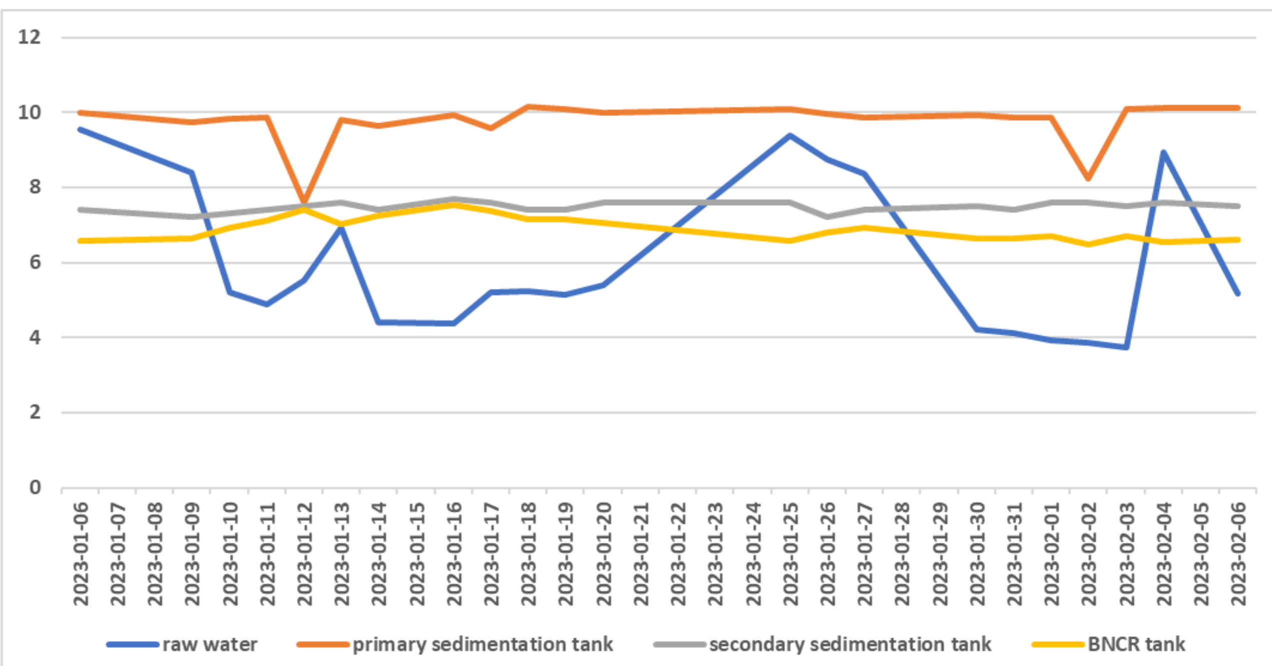

Figure 3: pH change graph

It can be seen that the pH of the raw wastewater flows in a wide variety of ways from pH 4 to pH 9, but after the primary sedimentation tank, the pH is maintained at about 7.5 after the secondary sedimentation tank, and the pH is about 7 after the BNCR tank. Since ammonia is dissolved in water in the sedimentation tank, the pH increases, and then the pH decreases as sodium hypochlorite denitrates in the BNCR tank.

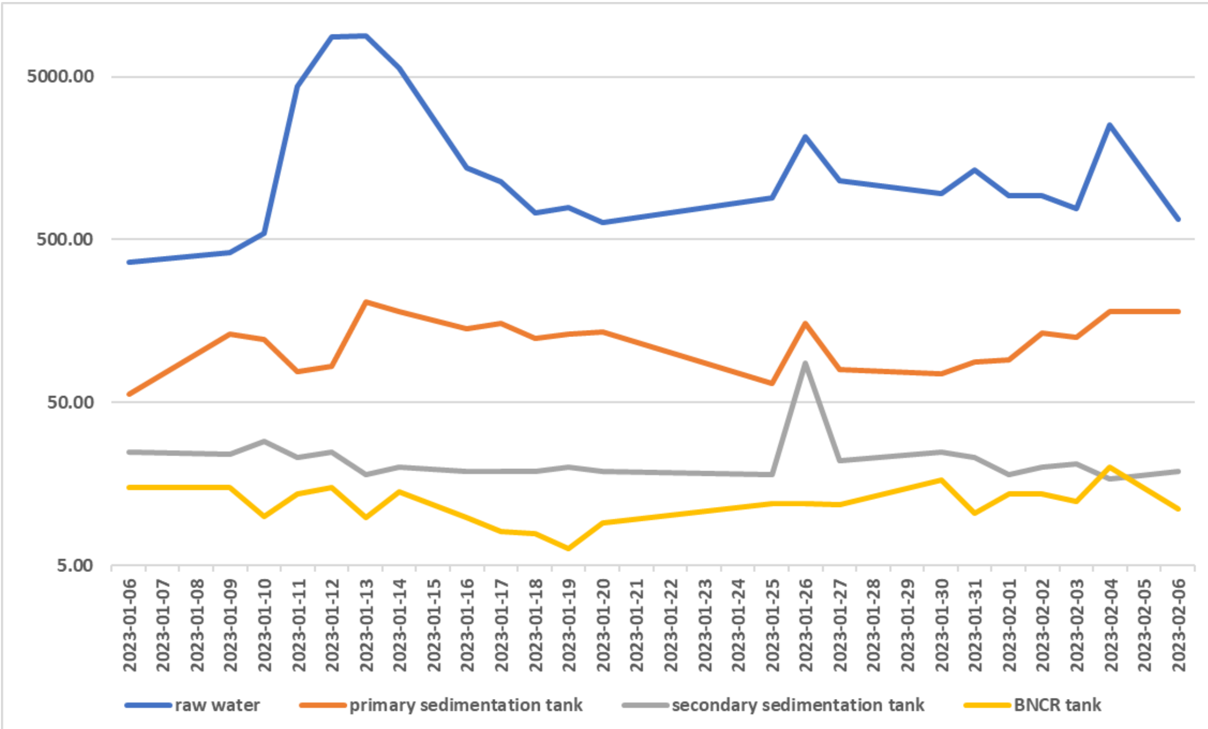

Figure 4: TOC change graph

TOC is reduced by about 98% of raw water as it passes through the sedimentation tank and the biological treatment tank, and after the BNCR tank, an average of 8mg/L remains.

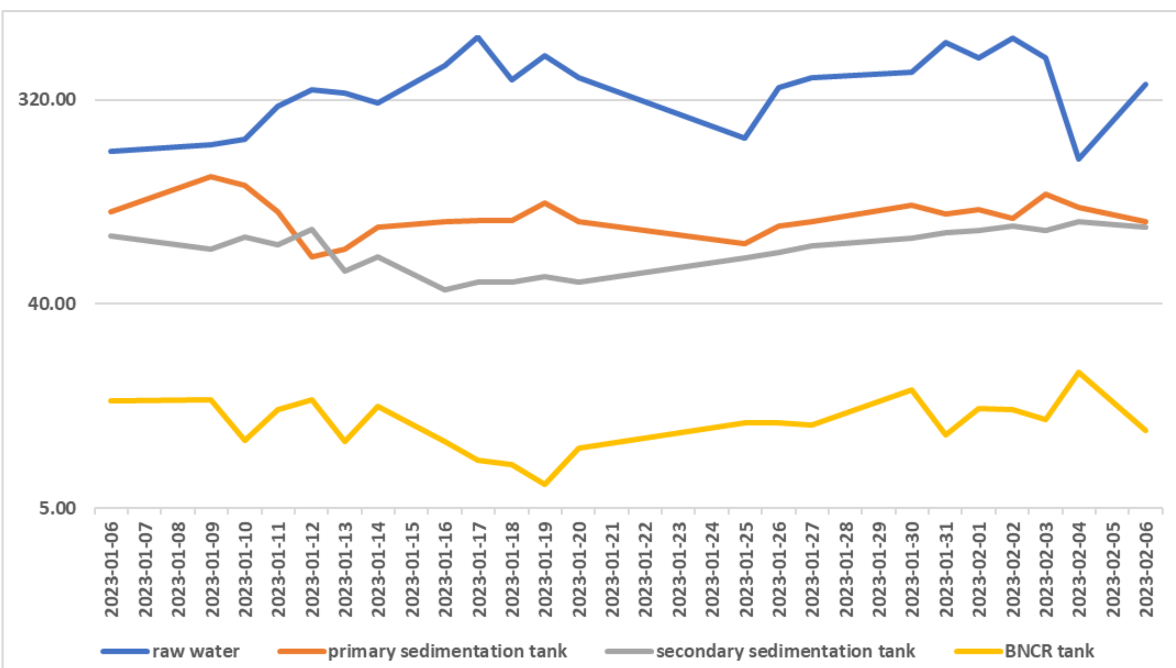

Figure 5: T-N change graph

Since the total nitrogen is not removed much from the sedimentation tank, it is removed only through the BNCR tank. After denitrification in the BNCR tank, the total nitrogen decreased by about 83% from an average of 70.91 mg/L in the secondary sedimentation tank to an average of 12.19 mg/L in the BNCR tank. In the secondary sedimentation tank, nitrogen is removed from the BNCR tank in excess of the legal standard of 60mg/L of total nitrogen discharge, and the final discharge is possible.

5. Conclusions

This study designed a process to remove ammonia nitrogen present in food desorption and demonstrated it for about a month to derive the ammonia nitrogen removal rate. The BNCR tank was designed to remove ammonia nitrogen and the method of removing ammonia nitrogen using sodium hypochlorite was studied, and the BNCR tank was designed to be in the stage behind the biological treatment tank(MBR).

Before flowing into the BNCR tank, organic substances were selectively removed by adjusting the operating time of the blower, and then introduced into the BNCR tank. As a result, it can be seen that the total nitrogen decreased by about 83% on average.

The process is considered to be worth using in other sewage treatment plants and wastewater treatment plants where ammonia nitrogen flows.

However, it is difficult to remove nitric acid nitrogen and nitric acid nitrogen with the method of this study, and carbon must be removed before ammonia nitrogen is removed to apply the method efficiently. In the biological treatment tank, the nitrogen removal rate increases when microorganisms use oxygen, make nitrogen in ammonia state, and then enter the BNCR tank.

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